LIQUID CONTAINMENT/DIVERSION DIKE

Field of the Invention

This invention is directed to a liquid containment/diversion dike and, in particular, a liquid-fillable containment/diversion dike for flood control or liquid containment, bladder elements for use in the dike and a method for construction of a liquid containment/diversion dike.

Background of the Invention

Many systems have been employed for controlling the spread of flood waters or fluid spills. One of the most common means for containing or diverting a flow of liquid is sandbagging wherein bags are filled with sand and piled to form a dike. Sandbagging to divert liquid flow has certain disadvantages including the cost of producing the sandbags and the difficultly in removing the barrier of sand bags when it is no longer required.

Summary of the Invention

A liquid-fillable liquid containment/diversion dike has been invented which can be used to contain or divert a flow of liquid such as a flood or a liquid chemical spill. The dike is easily transported and is fillable on site. When the dike is no longer required, it can be emptied of the liquid it contains and then transported to the next site where it is required. The dike is resistant to failure due to puncture because of a multiple bladder arrangement.

Thus, in accordance with a broad aspect of the present invention, there is provided a dike section having a length and comprising a first elongate bladder formed of a flexible

material to contain a liquid and a second elongate bladder formed of a flexible material to contain a liquid, the first elongate bladder and the second elongate bladder extending in side by side relation at least along a length of the dike; at least one wall dividing the first elongate bladder from the second elongate bladder, the wall formed to prevent any flow of liquid between the first elongate bladder and the second elongate bladder.

The dike section can have further bladders extending along the length thereof provided that at each cross section along the long axis of the dike section there are at least two bladders extending in side by side relation. The dike section includes at least one wall between at least two bladders, the wall being selected such that no fluid flow is permitted between the bladders. However, where the dike section includes more than two bladders extending in side by side relation, some of the walls between the bladders can have formed therein perforations to permit water flow therethrough in order to facilitate filling of the dike section with liquid.

Preferably, at least some of the bladders in a dike section are secured together. The bladders can be secured together in any suitable way. In one embodiment, the walls of some of the bladders are formed integral with each other. In another embodiment, the bladders are formed separately and are connected by any suitable means such as, for example, heat welds or fasteners such as rivets, belts or rope extending between the bladders or between apertures formed on the bladders.

The bladders are formed of any material which is flexible and which can contain water (i.e. water tight). As an example, the bladders can be formed of woven polyester or nylon fabric coated on one or both sides with urethane or vinyl. Preferably, the bladders are formed of 17 to 50 ounce woven polyester coated with vinyl on both sides. Any seams are sealed as by heat welding, adhesives or sewing to effect a liquid-tight seal.

Sealable ports are provided in each separate bladder to provide for access to the interior of the bladder for filling. Preferably, a one-way valve is provided at each port

for connection to an injection nozzle. In a preferred embodiment, a header device is provided having a plurality of connectors for simultaneous connection to a plurality of bladder valves. Such a header device provides that more than one bladder can be filled simultaneously. Preferably, all valves are positioned on the side wall of the bladder or on the end wall of the bladder proximal to a side of the bladder to facilitate filling of the bladder without collapse. To prevent overfilling, preferably a check valve is provided in a wall of the bladder. In one embodiment, a pressure transducer is positioned in communication with the interior of at least some of the bladders of the dike section so that an alarm will sound if the pressure in a bladder falls below a predetermined level.

To form a dike, one or more dike sections are positioned on the ground in substantially the final selected site of the dike and the bladders are filled with a liquid, for example, water from a potable water supply or surface water. A seal is effected between the dike section and the ground by the weight of liquid forcing the walls of the bladders into close contact with the ground and each other to prevent a passage of liquid therepast. Where more than one section is required to form the dike, the dike sections are positioned in end to end contact such that they seal against one another. The dike sections can be formed with ends of any shape provided they are formed to fit together with other dike sections to form a seal therebetween. Thus, the dike sections can be blunt, slanted or irregular at their ends. In one embodiment, the individual bladders of the dike sections are formed to be connected to the bladders of the abutting dike section.

In one embodiment, the dike section includes a pyramidal configuration of elongate bladders. As an example, there is a base layer of bladders positioned to extend in side by side relation. On this base layer are positioned a second layer of bladders. The number of bladders in the second layer is less than the number of bladders in the base layer. If possible, a third and further layers of bladders are positioned on the second layer. The walls of the bladders can be formed fully or partially integral with each other.

In one embodiment, the dike section is formed from a plurality of elongate dike bladders which are fully or partially separable.

It has been found that the operation of the dike section can be enhanced by preventing the water from seeping between the bladders. Thus, in one embodiment, a sheet of material can be partially or fully wrapped about the dike section at the intersection of abutting dike sections or along the length of a dike section. In addition or alternately, a sheet of material is positioned over the containment side of the dike section to extend a selected distance over the ground surface away from the dike section. The sheet of material is preferably liquid-tight.

In accordance with another broad aspect of the present invention, there is provided an elongate dike bladder comprising: a tube closed at its ends and having a wall and a long axis between the ends, the tube formed to be flexible and water-tight; and at least one port for access to the interior of the bladder.

In one embodiment, each elongate dike bladder is formed as a tube of flexible, water-tight material with a membrane extending across the interior of the tube parallel to the long axis thereof. Preferably, the membrane extends substantially across the diameter of the tube. The membrane can be solid or perforated. A bladder is primarily intended to be used in combination with other bladders for liquid containment or diversion. However, a bladder can be used alone for containment or diversion of a flow of liquid depending on the size of the flow of liquid and the size of the bladder. In such a situation, however, the bladder to be used should be one in which the membrane is solid and does not permit fluid flow through the membrane so that a puncture along the bladder will not result in a complete loss of water pressure in the bladder.

Another bladder according to the present invention is formed as a tube with closed ends and at least one of the ends is formed to be folded back on the bladder and maintained in this configuration by an end reinforcing sleeve. Such a bladder is producible at low

costs since a tube of water-tight material can be used and cut into any suitable length. Low cost welding procedures can be used to close off the ends of the tubes, since the ends do not independently withstand the pressure of the liquid within the bladder but instead are reinforced beneath the sleeve.

Brief Description of the Drawings

A further, detailed, description of the invention, briefly described above, will follow by reference to the following drawings of specific embodiments of the invention. These drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. In the drawings:

Figure 1A is a perspective view of a dike bladder according to the present invention, the end of the dike bladder being cut away to show the internal structure;

Figure 1B is a sectional view through a bladder plug useful in the present invention.

Figure 1C is a sectional view through a bladder side seam useful in the present invention.

Figure 1D is a perspective view of an end of a dike bladder according to the present invention.

Figure 1E is a side elevation view of another bladder according to the present invention shown partly in section.

Figure 2A is a perspective view of dike section according to the present invention, the end of the dike section being cut away to show the internal structure.

Figure 2B is a sectional view through a bladder seam useful in the present invention.

Figure 3 is a sectional view along lines 3 - 3 of Figure 2 showing the compression of the dike section by weight of water in the bladders.

Figure 4A is a side elevation view of two dike sections positioned in end to end configuration.

Figures 4B-a to 4B-c are schematic representations of a process for securing two bladders in end to end configuration.

Figure 5 is a sectional view through another dike section according to the present invention.

Figure 6 is a side elevation view of two dike bladders in end to end configuration during a liquid filling operation.

Figure 7 is an end view of another embodiment of a dike section according to the present invention.

Figures 8A to 8E are a schematic view of a dike construction operation according to the present invention.

Figure 9 is a sectional view through another dike section according to the present invention.

Detailed Description of the Present Invention

Referring to Figure 1A, a dike bladder 10 according to one aspect of the present invention is shown. Dike bladder 10 includes a wall 12 formed generally as a tube and

closed at its ends 14. A membrane 16 extends substantially diametrically across the interior of the bladder along its long axis, indicated as 18. Membrane 16 acts to strengthen the form of the bladder and to distribute outward forces acting on the bladder, when filled with liquid, to reduce the chance of bladder damage due to seam bursts. Membrane 16 can be solid, as shown, to prevent passage of liquid between chambers 20a, 20b separated by membrane 16. When solid, membrane 16 acts to isolate chamber 20a from chamber 20b to thereby prevent full collapse of the bladder should a leak occur in one of the chambers. Alternately, to facilitate filling of the bladder, membrane 16 can be perforated (Figure 2A) to permit liquid flow between chambers 20a, 20b.

Ports 22 having removable plugs 22a therein are disposed in the bladder wall for liquid injection into the chambers. Since, in the illustrated embodiment, no fluid flow can occur between chambers 20a, 20b, a port must be provided for each chamber. However, if membrane 16 is perforated, one port can be used to fill the entire bladder.

Referring to Figure 1B, a useful port/plug assembly is shown. Ports 22 preferably include a threaded insert 23 which is sealably secured into the material of wall 12 by use of a retaining nut 23a. Plug 22a is threadably insertable into insert 23. A suitable port and plug arrangement is, for example, an ABS flush drain valve secured into the wall of the bladder. Alternately, ports can have disposed therein one-way valves which can be fully opened to permit emptying of the bladder, when desired. Preferably, as shown, the ports are positioned proximate one side of the bladder to reduce collapse of the bladder during filling.

A pressure release valve 24 is also provided for each separate chamber of the bladder to prevent damage resulting from overfilling. A pressure detector 25a and a signalling means 25b is disposed in wall 12 of bladder 10 to monitor the pressure of the liquid in the bladder and to emit a signal when a pressure below a preselected pressure is detected. The signal can be, for example, an audible alarm or a radio signal etc. to a

monitoring panel. The pressure release valve and the pressure detector and signalling means can be mounted on the bladder in combination as one unit. Other valves and pressure detection and signalling means can be used, as desired.

Bladder 10 including the walls and the ends and, if desired, the membrane can be formed of any suitable flexible, water-tight material. In a preferred embodiment, bladder is formed of nylon- or urethane-coated polyester. Preferably, the material should be selected to have limited stretch. A particularly suitable material is available as Hurculite™. Any seams of the bladder can be prepared to provide a water-tight seal by folding, heat welding, adhesives and/or sewing. In the embodiment, as shown, the material is laid out in three layers and overlapping edges are folded and heat welded to effect a water tight seal. The folded portion forms a flange 26 which extends out from the bladder. Preferably, flange 26 includes reinforced apertures 28 formed therethrough for receiving fasteners for connection of adjacent bladders during dike construction. The use of fasteners with sharp edges should be avoided, however, to prevent puncturing. Preferably, ends 14 are formed without flanges to provide for close contact with any abutting bladders.

Other methods of bladder construction can be used, as desired. Referring to Figure 1C, another method of forming the bladder is shown wherein the walls 12 of the bladder are folded inwardly over membrane 16 and welded, as indicated at 29, in place.

Referring to Figures 1D and 1E, a cost effective and easy to produce bladder 10a is shown. Bladder 10a includes walls 12a formed of a tube of water tight material, such as Hurculite™, which has been rolled and heat welded to form a tube. The ends 14a of the bladder are closed by heat welding. Such a construction permits any length of bladder to be formed quickly and easily without the requirement for a complicated construction to close the ends. As would be appreciated, the pressure on ends 14a is great when bladder 10a is filled with water, thus, bladder 10a further includes end reinforcing sleeves 15a for use in reinforcing the end to permit filling of the bladder

without bursting the end seam. End reinforcing sleeves 15a are sized to maintain ends 14a in a condition folded back over the bladder. In a preferred embodiment, a length of bladder tube material is used for the end reinforcing sleeves. By using the tube material for both the bladder and the sleeve, the cost and ease of manufacture of the bladder are both enhanced. A sleeve having a length of 3 to 4 feet has been found suitable for use in reinforcing the ends of a 24" bladder. Preferably, the end of the bladder is folded back and the sleeve is placed around the end of the bladder and over the folded end when the bladder is in an empty or a partially filled state. As the bladder fills, it expands within the sleeve and the end is maintained firmly between the sleeve and the bladder. Sleeves 15a maintain ends 14a in a folded configuration and permits the bladder to be filled with liquid without concern about bursting the end seams. A preferred fill port 22 for such a bladder is a Munsen™ valve.

Bladders of any diameter and length can be formed. To facilitate transport and use, bladders of 10", 17" or 24" diameter and 50 foot lengths are preferred.

The bladders of the present invention can be filled with a liquid through their ports and used alone to divert or contain a flow of liquid. For containment or diversion of more significant flows, it has been found that it is advantageous to use bladders, generally as shown in Figures 1A to 1E, to form a dike section 30 as shown in Figures 2A and 3. Dike section 30 is shown generally schematically in Figure 2A as it would not appear in this form either when filled with liquid for use or when empty for transport. The same dike section is shown in Figure 3 with exemplary distortion of bladder shape by the effect of compression from the weight of the water within the bladders. Dike section 30 includes six bladders 10a to 10f generally as described in Figure 1. The bladders are arranged in three layers to form a pyramidal configuration. In particular, bladders 10a, 10b and 10c form a base layer, bladders 10d and 10e form a second layer and bladder 10f forms a third layer. Using bladder 10f as an example, each bladder includes a side wall 12f, a membrane 16f and ends 14f (only one can be seen as the other was removed from the drawing to permit illustration of the interior form). Bladder 10f is

formed having seams 32 sealed by rolling and welding. Seams 32 are substantially flush with the outer surface of the bladder. This enhances sealing contact with an optional dike wrap, as will be described and shown hereinafter.

Membrane 16f has formed therein perforations 34 to permit liquid flow therethrough. Preferably, perforations 34 are formed to extend along the width of the membrane, as shown, so that they extend parallel to the main stress vectors of the membrane to thereby not compromise the strength of the membrane. A single valve 22f is provided at an end of bladder 10f.

To permit construction in this pyramidal configuration, the base layer of bladders 10a to 10c must be secured together to prevent the outside bladders 10a and 10c from being forced out of position. Bladders 10a to 10c can be secured together in side by side relation in any suitable way such as, for example, by fasteners secured between flanges 26 or preferably by heat welding the bladders together or forming them integrally. Bladders 10a to 10c can be formed such that membranes 16a, 16b, and 16c are formed of a single sheet of material which extends from seam 32a to seam 32c. Sides 12a, 12b and 12c are applied on either side of the sheet of material forming membranes 16a to 16c and seams 32a, 32c and 36a, 36c are formed to seal the bladders from liquid communication with each other. Referring to Figure 2B, one method for formation of, for example, seam 36a is shown. To form seam 36a sides 12a and 12b are applied on either side of the single sheet of material intended to form membrane 16a, 16b. The ends 12a' of walls 12a and the ends 12b' of walls 12b are overlapped and sealed, as by heat welding indicated at 37, against membrane 16a, 16b.

Bladders 10d and 10e are also connected to prevent them from being forced out of position by the weight of bladder 10f. However, it is to be understood that bladders 10d and 10e need not be connected in this way as the forces imparted by bladder 10f may not be significant when compared to the amount of force required to move bladders 10d

and 10e out of the indents formed between bladders 10a and 10b and bladders 10b and 10c, respectively.

To construct a dike section as shown in Figures 2A and 3, bladders 10a to 10c are positioned on a ground surface 37. Bladders 10a to 10c can be separate and connected together with fasteners or other means or can be formed as single unit, as shown. The bladders will be in collapsed condition to ease transport and placement. After the bladders are in position on ground surface 37, water is injected into the bladders through their valves. Once bladders 10a to 10c are filled to a suitable pressure with water, bladders 10d and 10e, in collapsed condition are positioned in the indents formed between the bladders of the base layer. Bladders 10d and 10e are then filled with water to a selected fullness or pressure. The bladder 10f is then placed in the indent between bladders 10d and 10e and it is filled with water. The dike section is then ready for use to divert and/or contain a flow of liquid. In a preferred embodiment for use in flood control, a dike section of about 7' width by 5' height can be formed using six bladders of 24 inch diameter. Where a dike of greater height or strength is required, further bladders can be added against the dike and secured to the other bladders of the dike or larger bladders can be used. It has been found that the dike will act in an enhanced way to control a flow of liquid, where all of the bladders in a dike section are secured together.

The ends of dike section 30 can be formed in any suitable way to permit end to end abutment to create a water tight seal between the dike sections. One embodiment of a dike section 30a having an end which is slanted is shown in Figure 4A. In particular, dike section 30a is formed from a plurality of bladders including a base layer 40 of three bladders (only one of which can be seen), a second layer of two bladders 41 (only one of which can be seen) and a third separate bladder 42. The dike section is formed such that the end 42' of bladder 42 is recessed from the ends 41' of bladders 41 and, similarly, the ends 41' of bladders 41 are recessed from the ends 40' of bladders 40. This causes the end of dike 30a to be slanted, in side view, a particular angle α from

the long axis 44 of the dike section 30a. The angle α will depend on the degree to which the bladders are recessed from each other. The end of dike can be sealed against another dike 30b having a similarly slanted end. It would also be understood that dike section 30a having a slanted end can be rolled onto its side and used to form bends in a dike. The ends of the dike sections can have other forms, as desired.

Referring to Figures 4B-a to 4B-c, the ends of dike sections can be secured together in a convenient way when bladders as shown in Figures 1D and 1E are used. In particular, the ends 14a', 14a" of abutting bladders 10a', 10a" can be rolled together and secured in this rolled configuration using an end reinforcement sleeve 15a. Figure 4B-a shows the first step in which abutting bladders 10a', 10a" are set in position for use with their ends 14a', 14a" in overlapping configuration. Ends 14a', 14a" are then rolled together (Figures 4B-b and 4B-c) and sleeve 15a is placed over the rolled ends. The water is then provided to fill the bladders so that they expand within the sleeve and are maintained in the rolled configuration by the sleeve.

Referring to Figure 5, a sectional view through another dike section 30b is shown including a plurality of bladders and wherein the walls between the bladders are formed integral. The six bladders 10' are not separable each from the other. The walls 12' of the bladders are solid such that no fluid communication is possible between the bladders. This prevents total failure of the dike section where a puncture occurs in one of the bladders. Dikes containing other numbers of bladders can be made. A dike, as illustrated in Figure 5, can be made by any suitable means such as, for example, by extrusion or pultrusion.

To facilitate the filling operation of a dike section, preferably a header system is used. Figure 6 shows one header arrangement wherein bladders 110a, 110b are formed with ends 110a' and 110b' intended to be abutted together to effect a seal therebetween. Valves 122 are positioned adjacent ends 110a' and 110b' and in communication with the interior of the bladders. A header connector 150 is provided for removable

attachment to the valves 122. Preferably header connector 150 is formed of flexible hose to permit some adjustment depending on the spacing of valves 122. Header connector 150 has positioned thereon a valve 152 for connection, for example to a fire hose (not shown). During a dike construction operation, bladders 110a, 110b can be positioned so that their ends 110a' and 110b' carrying the valves 122 are in end to end configuration. Header connector 150 can be attached to valves 122 and a hose (not shown) can be connected at valve 152. Water from a water source can be supplied through the hose and into the header to be distributed to bladders 110a, 110b.

Referring to Figure 7, more complex header 160 can be provided to permit simultaneous filling of a plurality of bladders. Header 160 includes a main valve 162 for connection to, for example, a fire hose nozzle. A plurality of flexible tubes 164 extend between valve 162 and bladders 110' of a dike section. Positioned in each tube 164 is a one-way valve 166 which permits liquid to pass therethrough into the bladder but prevents liquid from passing from the bladder back towards valve 162. Thus, water can be injected simultaneously into all of the bladders connected to valve 162, but water cannot be drained out of the entire dike section by a puncture in one of the bladders.

Referring to Figures 8A to 8E, the construction of a dike according to the present invention is shown. A bladder unit 209 containing four bladders 210a is rolled out in a selected position on a ground surface 37. Bladders 210a are connected by seams 236a so that they cannot move apart, but seams 236a prevent liquid communication between the bladders. Each bladder includes a one-way valve 222 for injection of water into the bladder. A header connector 250 is connected to a water hose 256 which is communication with a water source 257. Header connector 250 is connected to valves 222 and water is passed from the source to the bladders to fill the bladders to a selected level. The header connector is then removed from valves 222. The point at which the bladders are properly filled can be determined by timing, observation of the nature of the bladders, pressure release valves 224 or using other means. Other

methods can be used for filling the bladders, but use of a header facilitates the filling operation.

Once bladders 210a are filled to a suitable pressure with water (Figure 8B), a unit 211 including three bladders 210b, in collapsed condition, is positioned on top of unit 209. Bladders 210b are then filled with water in a similar manner as that described hereinbefore. During the filling operation, bladders 210b will, by gravity, drop into the indents between bladders 210a.

A further unit 213 containing two bladders 210c is positioned onto unit 211 and filled. Finally a top bladder 210d is placed on top of the other units and is filled with water. The construction of dike section 230c is then complete (Figure 8C). Preferably, each bladder is connected to at least one other bladder to increase the strength of the dike section.

A second dike section 230d is constructed to be in abutting relation to dike section 230c (Figure 8D) and other dike sections can be added to produce a dike of selected length.

Where the flow of liquid to be contained or diverted increases beyond the size of dike section 230c, further bladders can be positioned adjacent the dike section, filled and secured to the dike section.

To reinforce the end to end connection a wrap 258 can be positioned around the end to end connection (Figure 8E). Wrap 258 can be formed of plastic material or any other material of suitable strength and which will not break down when in contact with the liquid to be contained or diverted. The constructed dike is then ready to be used to divert and/or contain a flow of liquid.

Referring to Figure 9, it has been found that the functioning of the dike section 230e can be enhanced by placing a wrap 258a over the entire length of the dike section. Wrap

258a preferably extends from at least a portion of the way beneath the dike section (ie. between the dike section and the ground surface 37 on which it is placed) over the containment side of the dike section to a position above the level of the fluid 260 to be contained.

Where a greater strength dike is required, another sheet of substantially liquid-tight material 262 is extended over the containment side of the dike section to extend out a selected distance from the dike over the ground surface on which the dike section is placed. It has been found that for a flows at depths of about 6 feet, a sheet of material extending about 10 to 15 feet from the dike increases the strength of the dike.

It will be apparent that many other changes may be made to the illustrative embodiments, while falling within the scope of the invention and it is intended that all such changes be covered by the claims appended hereto.